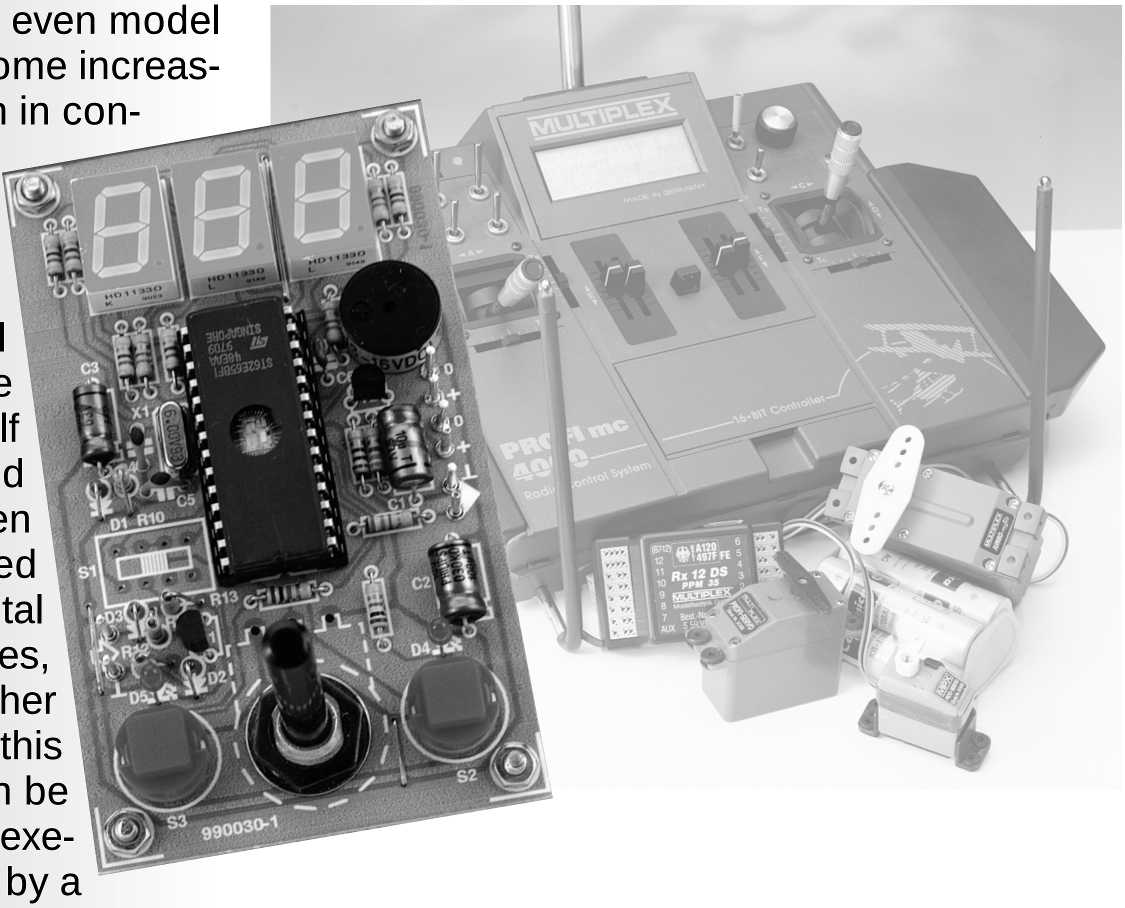
servo tester

with a built-in pulse generator

Nowadays, even model builders come increasingly often in contact with microcontrollers. Not only is the control of the model itself more and more often implemented using digital techniques, many other tasks in this hobby can be perfectly executed by a microcontroller. In this article, we present an intelligent tester for servo controllers. It generates servo pulses and can also measure pulse parameters.



Design by B. Stuurman

Servo pulses play an important role in controlling the operation of models. The motor speed, direction of travel and other aspects are all controlled by servo pulses. For the uninitiated, a brief explanation of servo pulses is in order. A servo pulse is a digital signal that is generated with a repetition interval of 20 milliseconds. The pulse width ranges from a minimum of 1 ms to a maximum of 2 ms. The 'neutral' width is around 1.5 ms. **Figure 1** shows an individual servo pulse.

The servo converts servo pulses into mechanical motion. If the pulse width is 1 ms, the servo position is at one extreme, while if the pulse width is 2 ms the servo position is at the other extreme.

The servo tester can measure both the width and the repetition interval (period) of a servo pulse. It can also generate pulses itself for testing servos. The tester is designed to produce a minimum pulse width of 0.7 ms and a maximum pulse width of 2.5 ms, so that all types of servos can be thoroughly tested.

THE DESIGN

Figure 2 shows the design of the servo tester. It is based on a ST62T65B IC, a powerful microcontroller made by SGS Thomson. This controller has two full 8-bit ports (PA and PB) and a 5-bit port (PC). The ports have slightly different characteristics. Port B can switch currents up to 20 mA to earth, while port

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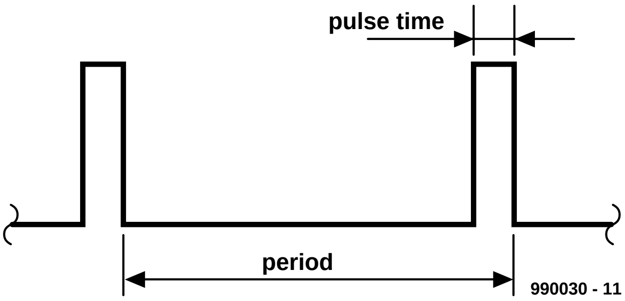

Figure 1. The servo signal is a pulse-width modulated signal with a repetition interval of 20 ms. The pulse width ranges from 1 ms to 2 ms.

A can handle currents up to 5 mA in both directions. The hardware design takes these factors into account, so that the individual segments of the display are connected to port A while the cathodes (which carry the heavier currents) are connected to port B.

Pin PC1 of port C is used as the input. This pin is connected directly to a built-in timer. The timer runs if a high level is present on this pin, and it is halted if a low level is present. This hardware coupling guarantees high precision for the measurements. The input circuit, consisting of T1, D2, D3, R11, R12 and R13, acts as an emitter follower that buffers the input signal without changing its polarity. The diodes provide protection against excessive input voltages.

With the chosen clock frequency (6 MHz), the integrated timer counts in steps of 2 µs. This reduces the amount of computation that has to be performed by the controller.

The controller also has a timer with an adjustable interval. The output of this timer, pin PB7, is connected to an output amplifier consisting of T2, R14 and R15. The servo pulses that appear on this output can be used to directly control a servo. This signal is also made available to the controller via switch S1.

The rest of the hardware is formed by switches S2 and S3, LEDs D4 and D5, seven-segment displays LD1 through LD3 and a buzzer. Finally, R10, C3 and D1 form a reset circuit. This ensures that the controller is properly initialized when the power is switched on.

Switch S1 has three positions. Position 1 selects the period measurement function. In this mode, the input of the circuit is connected to pin PB6, while pin PC4 is connected to pin PC1. The software provides the PC4 input with a 2:1 divider, which is advantageous for making period measurements. With this

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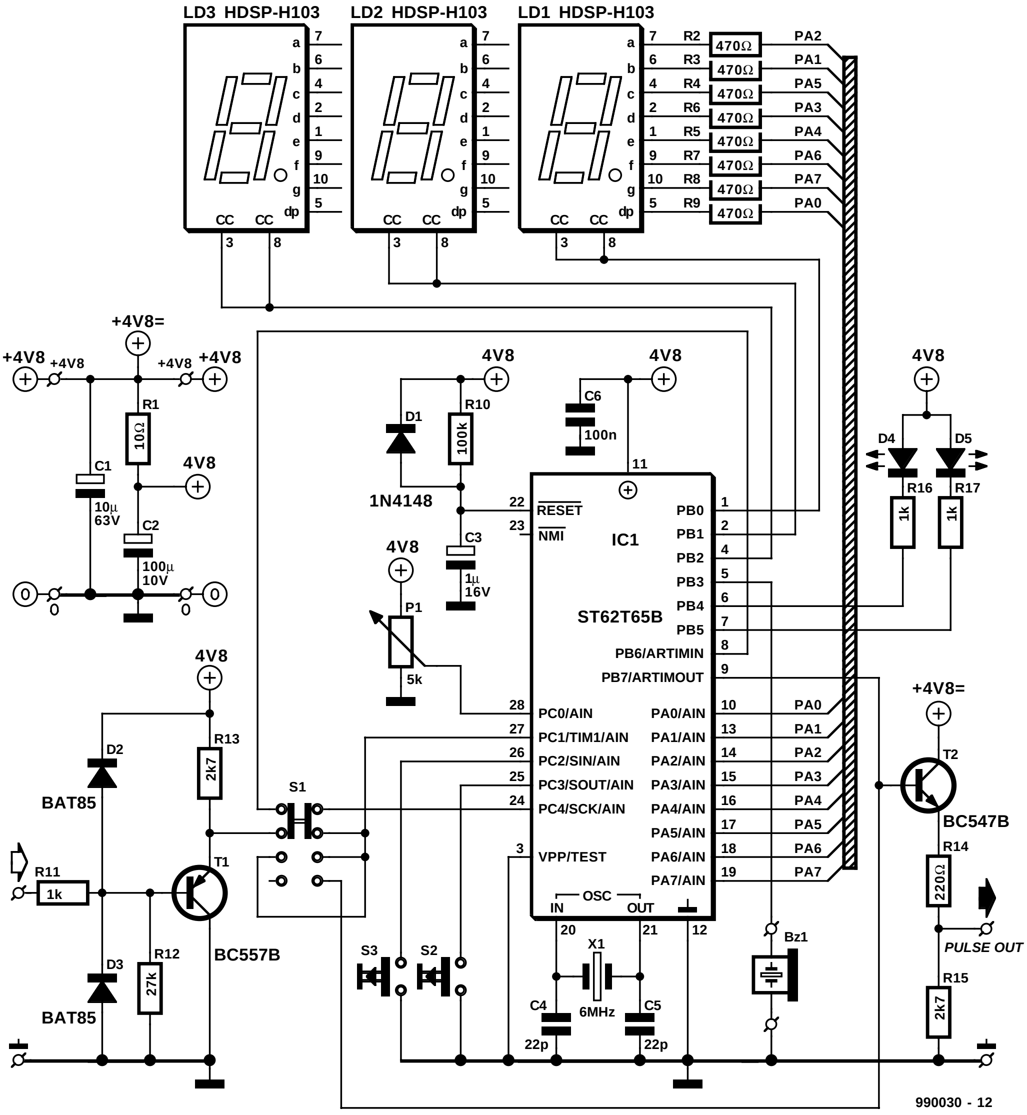

Figure 2. This circuit can be used for testing servo signals as well as servos.

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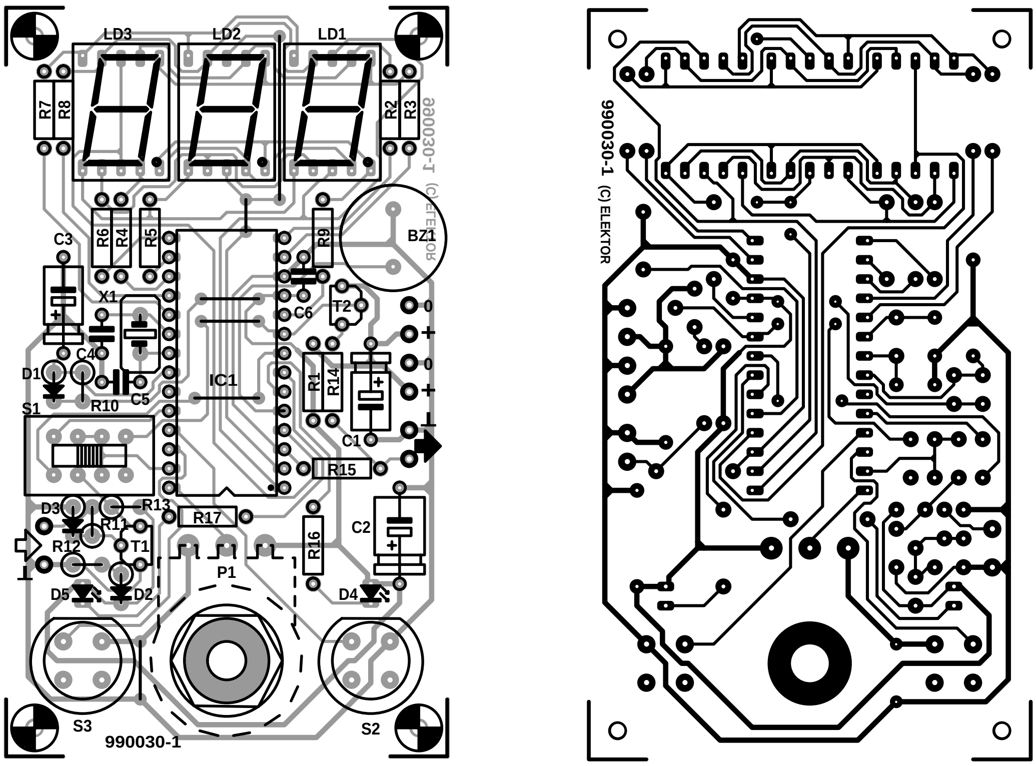

Figure 3. The complete circuit can be built on this ready-made printed circuit board.

COMPONENTS LIST

Resistors:
R1 = 10Ω
R2-R9 = 470Ω
R10 = 100kΩ
R11,R16,R17 = 1kΩ
R12 = 27kΩ
R13,R15 = 2kΩ7
R14 = 220Ω
P1 = 5kΩ potentiometer, linear

Capacitors:
C1 = 10µF 63V
C2 = 100µF 10V
C3 = 1µF 16V
C4,C5 = 22pF ceramic
C6 = 100nF ceramic

Semiconductors:
D1 = 1N4148
D2,D3 = BAT85
D4,D5 = LED, red, high efficiency
T1 = BC557B
T2 = BC547B
IC1 = ST62T65B (order code 996507-1)

Miscellaneous:
X1 = 6 MHz
LD1,LD2,LD3 = HDSP-H103, high efficiency, common cathode, Siemens
S1 = slide switch, 3 positions, 2 poles (Knitter switch type MFP-230)
S2,S3 = pushbutton D6-R-RD (ITC)
Bz1 = passive piezo buzzer type SEP 2242
PCB: order code 990030-1 (see Readers Services pages)
3.5" disk with source code file: order code 996008-1 (see Readers Services pages)

divider, the period can be measured using the same routine that is used for measuring the pulse width.

In position 2, the circuit input is connected to pin PC1. This mode is used for measuring the width of the servo pulse.

Position 3 is also used for pulse width measurement, but in this case pin PB7 is connected to pin PC1 and the controller measures the width of the pulse that it generates itself.

Note that switch S1 is a special type. It has two rows with four contacts each, instead of the usual two rows with three contacts each. In each position, two adjacent contacts are connected to each other. Make sure that you purchase the correct type!

Potentiometer P1 can be used for various adjustments, such as manually setting the pulse width and setting the minimum and maximum pulse widths. The two pushbutton switches S2 and S3 are used to enter settings for the minimum and maximum pulse width, respectively. LEDs D4 and D5 indicate the entry of these values.

The 4.8 V supply voltage for the circuit is simply borrowed from the receiver supply.

PRACTICAL ASPECTS

Regardless of how nice the tester may look on paper, what counts is how it works in practice. To test this, you must first build the circuit. This is made a lot easier by a ready-made printed circuit board, available through the Publishers' Readers Services. **Figure 3** shows the copper track layout and the component layout.

Building the tester should not present any particular difficulties, since the component placements are clearly indicated. Don't forget the three wire links that have to be inserted under the controller socket. It's all too easy to overlook them.

The best way to connect a servo is to use a servo extension cable with one end cut off. You can quickly make a good electrical connection with such a cable. **Figure 4** shows the connection schemes for a number of different types of servos. This should help you to properly connect your own servos to the tester.

AND NOW TO WORK!

Using the tester is remarkably easy. Once you have decided what sort of measurement to make, the actual measurement process requires no more than selecting the correct mode, connecting the signal or the servo to be measured or tested, and reading the test result from the bright LED display.

To measure the period of a servo pulse, put switch S1 in position 1. The measured period will be shown on the LED display in units of milliseconds. The repetition rate of the servo signal can be calculated by dividing 1000 by the measured period in milliseconds.

If the pulse width or period is longer than the maximum value that the tester can measure, 'HHH' is shown on the display. If the input level is low for the duration of the entire measurement, all the bottom segments of the display are illuminated. If by contrast the input level is high for the duration of the measurement, all the topmost segments are illuminated. Note however that these low and high level indications are only possible for pulse width measurements, due to the use of a 2:1 divider for period measurements.

To measure the width of a servo pulse, put switch S1 in position 2. Connect the input of the tester to the servo output of a receiver. The pulse width will be shown on the display, with a resolution of two digits after the decimal point.

When switch S1 is in position 3, you can read the width of the test servo pulse on the display. This value will change if P1 is adjusted, and the width of the test servo pulse will change accordingly. If a servo is connected to the tester output, it will follow the rotation of potentiometer P1.

Automatic testing of a servo is also possible. To do this, press S2 (Set Low) and S3 (Set High) simultaneously. The servo will now move back and forth between its minimum and maximum positions. You can change the speed at which this occurs by adjusting P1. Briefly press either S2 or S3 to restore normal manual operation.

The minimum and maximum widths of the test pulse can be easily programmed. If you press and hold the Set Low pushbutton (S2), the associated LED will be illuminated. You can read the current setting of the minimum pulse width on the display. Adjust potentiometer P1 until the desired width is displayed, and then release S2. Similarly, the maximum pulse width can be read and if necessary adjusted by means of the Set High pushbutton (S3). The minimum and maximum pulse-width settings are stored in the EEPROM of the controller.

If the selected value for the minimum pulse width is greater than that for the maximum pulse width, the circuit will give an error indication: the buzzer will beep and both LEDs will be illuminated. In this way, you are prevented from selecting an erroneous set of values.

With all of the features that this tester provides, you can use it for quickly checking and testing receivers as well as servos. It is a compact and handy piece of test equipment, as will you will quickly find once you have used it a few times!

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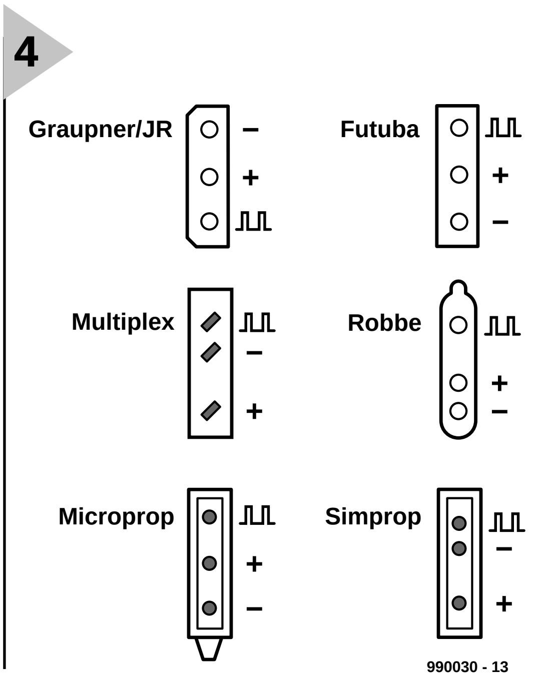


Figure 4. There are several manufacturers of servos, and each of them uses a different type of connector. This summary should help to clarify the situation.

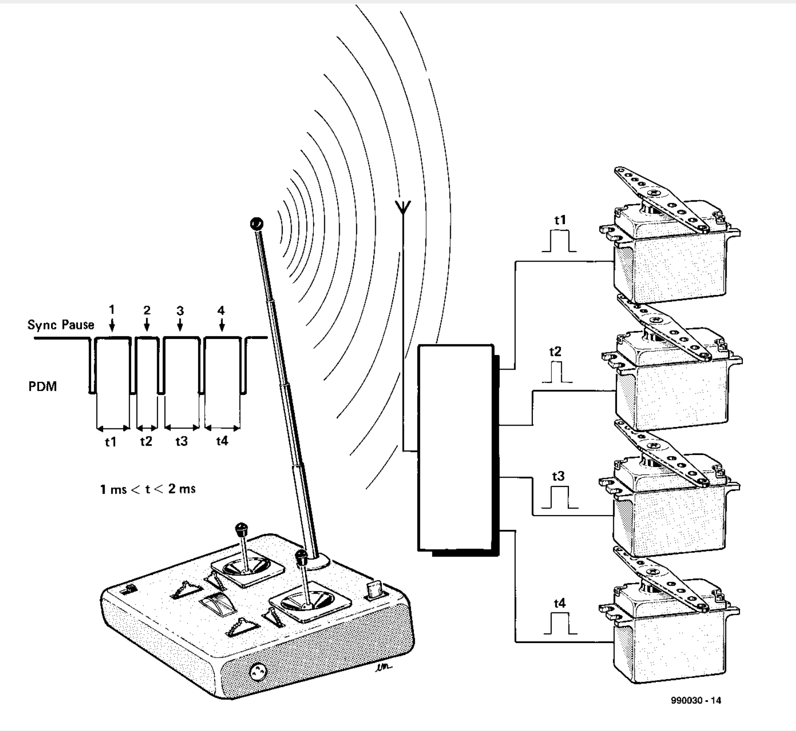
Model control with servos

Every model builder uses servos. They are connected directly to the servo output of a receiver in the model to be controlled, be it a car, a boat or an aeroplane. Several servos are commonly used in a model to control the direction of travel (left/right and up/down) and the speed. The diagram shows how four servos can be remotely controlled via a four-channel transmitter and four-channel receiver.

The actual control takes place via repetitive voltage pulses. These are labelled t1 through t4 in the drawing. The repetition interval for any given pulse is 20 ms.

The width of each pulse is variable, and in practice it ranges from 1 to 2 ms. With proportional control, all intermediate values are possible. Non-proportional (binary) controllers, which are used with inexpensive models, switch between one extreme and the other — which, by the way, does not actually require the use of a servo.

The servo itself contains a miniature electric motor that drives the item to be controlled. In addition, the rotation of the motor changes the position of an internal potentiometer. This potentiometer, which has a resistance of around 5 kΩ, controls a monostable multivibrator that is also housed in the servo. Built-in electronics serve to keep the width of the internally-generated pulse equal to that of the input pulse. Since there is a fixed relationship between the angle of rotation of the potentiometer and the pulse width, the amount of rotation of the servo motor can be directly controlled by the width of the applied pulse.



A conventional 'digital-proportional' PWM system. The servo positions are controlled by pulses whose widths can be varied between 1 and 2 ms.